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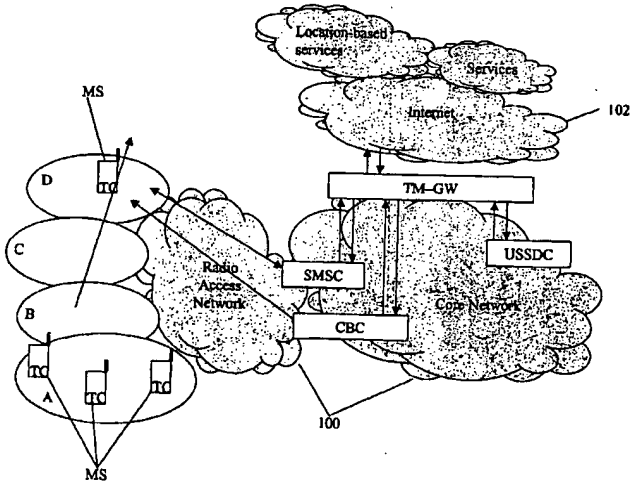

(57) Abstract: The invention provides a method and arrangement for locating a cellular mobile station in a cellular mobile network. A terminal-based location arrangement in the cellular mobile network for locating and tracking the cellular mobile station is applied. The cellular mobile station(s) independently stores cellular network location information in a time dependent manner depending on a certain criteria for updating the location information. A timestamp indicating a point of time for current cellular network location information can be applied. The criteria for storing the location information and the timestamp can be that the cellular mobile station moves to another cell. The location information stored in the cellular mobile station can be transmitted to the location-based services. The transmission can be based on triggering being based on location criteria or a point-to-point request messaging. Broadcast messaging can be applied for the triggering for delivering the location criteria to the cellular mobile station. The location criteria establish a target route, and traveling the route triggers the transmission of the location information.

METHOD AND ARRANGEMENT FOR TRACKING A CELLULAR MOBILE STATION

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to cellular communications, and more particularly, to methods and arrangements for tracking mobile users.

BACKGROUND OF THE INVENTION

The increasing demand for personal communication services (PCS) requires wireless networks to gracefully accommodate mobility of both users and services. Contrary to wire-line networks, in which user location is fixed, in wireless networks a user can potentially be located anywhere within the system service area. As the number of mobile users keeps increasing, the amount of signaling traffic required for location management keeps growing. The cost associated with the need to locate a mobile user is composed of three parts: 1) The cost of accessing databases, such as Home Location Register (HLR) and Visitor Location Register (VLR), 2) The cost of radio signaling over the control channel, 3) The cost of other location techniques than those based on the cellular mobile system for enabling the mobile terminals to be located.

The problem of tracking mobile users has been addressed by several studies, many of which attempt to reduce the wireless cost of user tracking. For example, in cellular system such as Global System for Mobile Communications (GSM) there is being developed several location systems and some have entered the market. However, the common problem for those solutions is yet that they use and consume the communication resources, for example signaling resources, plenty, and that they store the location information only after the location process is activated.

It is far too difficult to provide large number of subscribers with the location-based applications or services in the cellular based network (such as GSM network), because the applied location systems are not applicable to track and locate large number of subscribers in short period. The current network based location systems require certain locating process time which is relatively long. The more the users

there are to be located, the more locating process time the system requires. In most cases in the network-based location systems, the mobile terminal must be at least momentarily invoked, for example by performing a fake call, that the location of the mobile terminal is obtained with at least the accuracy of a cell. The required invoke procedure or similar detecting procedure needs and uses the resources of the network.

The current terminal-based location systems (such as Enhanced Observed Time Difference (E-OTD), Assisted Global Positioning System (A-GPS)) fit well for larger number of subscriber. However, the subscribers must replace and purchase new terminals which are adapted to the E-OTD or A-GPS. Obviously this creates costs as, for example, a GPS receiver has to be integrated into the terminal. Moreover, because the power is a critical element for mobile terminals, and the current terminal-based location systems must apply a separate processing in the reception of the location system signal, the current terminal-based location systems waste the power of the mobile terminal. For example, the reception and the locating based on the E-OTD requires substantially increased processing power in the terminal.

In view of various inherent limitations of mobile devices and systems, it would be desirable to avoid or mitigate these and other problems associated with prior art systems. Thus, there is a need for techniques to provide cost effective and resource sparing location system for mobile users.

SUMMARY OF THE INVENTION

Now a method and a system have been invented where a mobile device is tracked in terminal-based location manner.

In accordance with a first aspect of the invention there is provided a method for terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the method comprising the steps of:

receiving cellular network location information from the cellular mobile communication network at the cellular mobile station, and

storing, at the cellular mobile station, the cellular network location information and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

In accordance with a second aspect of the invention there is provided a system for terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the system comprising:

the cellular mobile communication network for providing the cellular mobile station with cellular network location information, and for transferring a message between the cellular mobile station and a gateway,

a RF section for receiving cellular network location information from the cellular mobile communication network at the cellular mobile station,

means for storing, at the mobile station, cellular network location information and a timestamp for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network,

the gateway for bridging communication between the cellular mobile communication network and a computing network, and for receiving a message containing stored cellular network location information and timestamps from the cellular mobile station for determining a traveled route of the cellular mobile station, and

a location-based service server in the computing network for providing location based service for a user.

In accordance with a third aspect of the invention there is provided a cellular mobile station for terminal-based tracking, the cellular mobile station adapted to operate in a cellular mobile communication network, the cellular mobile station comprising:

a RF section for receiving cellular network location information from the cellular mobile communication network at the cellular mobile station, and

means for storing, at the cellular mobile station, cellular network location information and a timestamp for each piece of cellular network location information

indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

Advantageously, the mobile communication system is less burdened while applying the terminal-based locating. The cellular mobile communication networks provide location information anyway, and some are even obliged to provide certain location information. The terminal merely collects and stores the location information, and only transferring the location information and timestamps or the transfer of triggering criteria for reporting stress the network resource. The location information can be real-time data for currently tracking the location of the mobile station. Moreover, the location information of the mobile station can be stored with history so that the location and the corresponding point in time can be obtained. Installing can be fairly simply by just inserting an applicable SIM card into the terminal. Also, the locating application can be downloaded into the terminal. A large number of subscribers/users can be continuously located and tracked.

In accordance with a fourth aspect of the invention there is provided a releasable attachable data card for a cellular mobile station adapted to operate in the cellular mobile communication network, the data card comprising:

an interface for receiving cellular network location information from the cellular mobile communication network, and for being coupled with a RF section of the cellular mobile station, and

means for storing, at the data card, the cellular network location information and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

In accordance with a fifth aspect of the invention, there is provided a computer program product comprising a program of instructions executable by a computing system for processing terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the computer program product comprising:

computer program code for causing the system to receive cellular network location information from the cellular mobile communication network at the cellular mobile station, and

computer program code for causing the system to store, at the cellular mobile station, the cellular network location information and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

For better understanding of the present invention reference is made to the following description, taken in conjunction with the accompanying drawings, and its scope will be pointed out in the appending claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 depicts an embodiment of a networking environment in which the principles of the invention are applied,

Figure 2 depicts in a form of a flow chart a method for a terminal-based locating in accordance with an embodiment of the invention,

Figure 3 depicts in a form of a flow chart a method for a terminal-based location in accordance with gateway embodiments of the invention,

Figure 4 depicts in a form of a flow chart a method for a terminal-based location in accordance with broadcast based gateway embodiments,

Figure 5 depicts an exemplary cellular mobile station for terminal-based location in cellular mobile network in accordance with an embodiment of the invention,

Figure 6 shows an exemplary location information table,

Figure 7 shows exemplary location information criteria.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The preferred embodiments of the invention provide a method and a system for locating a cellular mobile station in a cellular mobile network. The preferred embodiments provide a terminal-based location arrangement in the cellular mobile

network for locating and tracking the cellular mobile station. Advantageously, the cellular mobile station(s) independently stores cellular network location information in a time dependent manner periodically or depending on a certain criteria for updating the location information. Advantageously, a timestamp indicating a point of time for current cellular network location information is applied. The criteria for storing the location information and the timestamp can be a substantial change in the location information, for example, when the cellular mobile station moves into another cell. Advantageously, the location information stored in the cellular mobile station can be transmitted to the cellular mobile communication network. The transmission can be based on a triggering being based on location criteria or a point-to-point request messaging. Broadcast messaging can be applied for the triggering for delivering the location criteria to the cellular mobile station.

Cellular network location information is stored in the cellular mobile station by a Track Controller (TC) application which is operating in the station. Cellular network location information is stored when the cellular mobile station moves or changes a cell. The TC application is contained in a Subscriber Identity Module (SIM) card. Moreover, Universal Subscriber Identity Module (USIM) applicable for UMTS can be applied. Alternatively, the TC application can also be stored in the memory of the cellular mobile station. A Java-based interface can be applied for a communication between the SIM and the terminal. Moreover, a shared appliance of the SIM and the terminal memory can be applied for TC application, or the TC application or the location information can be transferred from one memory space into another.

Basic principles of the cellular network embody the invention. The TC application accommodated in the cellular mobile station, a Track Master Gateway (TM-GW) bridging communication between the cellular network and packet-based network such as Internet are applied. Advantageously, the embodied invention can be installed with quite small efforts into the existing operating GSM environment or into evolvements of the GSM.

Some embodiments of the invention provide the TC application accommodated in the cellular mobile station. The TC application marks down cellular network location information, for example Cell Global Identity (CGI), by storing data into the SIM card. Moreover, the timestamp indicating a certain point in time is stored for each piece of cellular network location information. The storing is performed when a certain condition is fulfilled. For example, a change in cellular network location information triggers the storing. For example, if the cellular mobile station

moves into another cell, the location information changes accordingly, and the storing takes place. For another example, the checking of the change of cellular network location information is performed periodically. Alternatively, the storing of cellular network location information takes place periodically after a certain time limit. A ring/loop buffer is applied as a data structure for storing cellular network location information and the timestamp, and the oldest location information is overwritten if necessary. The TC application can be implemented as a SIM Toolkit application. Alternatively, the TC application is operating directly on the operating system of the station, or the TC application is running in a virtual machine in the station. When applying the SIM accommodation, the TC application continuously stores cellular network location information that can be retrieved by point-to-point based SMS/USSD messages to an appliance of an external location-based application via the Track Master Gateway (TM-GW). Alternatively, the cellular network location information can be retrieved/requested from desired cellular mobile stations by sending a broadcast message to certain cell/cell areas, the broadcast message setting certain criteria, by which the reporting of the location information table is possible. Every cellular mobile station receives the broadcast message but only the cellular mobile station(s), which has traveled a target route, shall report to the network. The transmission channel used for transferring the location information and the timestamps of the cellular mobile stations can be defined as selection criteria-specific.

Advantageously, the appliance of the criteria significantly reduces tracking/locating application's load to the network compared to network-based or separate locating systems. The preferred embodiments stress the network only when the location information table is transferred/responded to the network. The actual gathering of the location information, which the network is providing/broadcasting, does not cause any load to the network transmission resources, because, for example, the cellular network anyway periodically transmits the CGI information. In addition, the broadcasted criteria can reach various cellular mobile stations by a single broadcast message.

Some embodiments of the invention apply cellular network location information. Cellular network location information comprises a way to indicate a certain location area under which the receiver is located. Thus, the network is providing the receiver with location information that indicates that the receiver is under coverage of certain area of the network. Cell Global Identity (CGI) information uniquely identifies the

geographic location in GSM network. The CGI information comprises a Mobile Country Code (MCC, 3 digits/10 bits), Mobile Network Code (MNC, 2-3 digits/10 bits), Location Area Code (LAC, 5 digits/16 bits or less) and Cell Identity (CI, 5 digits/16 bits). Thus, the CGI code occupies approximately 7 bytes memory space. Cellular network location information is provided by the cellular mobile communication network. Thus, the network provides or transmits the cellular network location information in broadcast dependent manner to the cellular mobile station. The GSM network is even obligated to provide some CGI information. Therefore, location information is always available if the cellular mobile station is under coverage of the network. The cellular network provides the location information, but the actual cellular network is aware of the location of the cellular mobile station only with accuracy of the LAC, and the LAC is always larger area than the cell. Therefore, the terminal-based location storage is applied. Cellular network location information is furnished with a timestamp. Therefore, the stored location information can contain the timestamp. Cellular network location information and the timestamp are stored in location information table (LIT) which is contained in the memory space of the terminal. The oldest location information (and timestamp) is automatically erased, or overwritten when adding new location and timestamp information if the table is full. Thus, the location information table is saved in a ring or loop based memory space.

Terminal's (or SIM card's) memory capacity sets boundaries for the amount of the stored LIT containing cellular network location information and the timestamps. Advantageously, the bit amount of the CGI information and the corresponding timestamp is small. Therefore, a lot of history data can be saved and the preferred embodiments of the invention for determining a traveled route of the cellular mobile station can be effectively utilized. The more the history data grows in the location information table, the better the location can be applied for the TC application and location appliances.

The location information can be queried by point-to-point messages. Alternatively, broadcast messages can be used to perform the query. Preferably, the location criteria trigger the delivery of the cellular mobile station's location information table.

Some embodiments of the invention apply the point-to-point based messaging. The point-to-point message is transferred between the cellular mobile station and the cellular network. The point-to-point messaging can comprise a report or response

message sent from the station to the network, or on the contrary the point-to-point message can comprise a request/query sent from the network to the terminal. Point-to-point based location request contains a certain time period (start/end time), a return channel for transferring the location information table (for example, SMS/USSD/GPRS), and an address of the server to which the location information is sent (for example, TM-GW's service number/URL). When the TC application of the terminal receives the point-to-point location information request from the network, the terminal responses and sends the requested location information and timestamps to the network via the applied data channel. Alternatively, the history data or the current location data can be requested separately.

Some embodiments of the invention apply the broadcast based messaging. The broadcast based message contains location information criteria, the return channel for the transmission of location information, for example SMS/USSD/GPRS, and an address of the server to which the location information is sent (for example, TM-GW's service number/URL).

Referring to the example of the broadcasting. All cellular mobile stations are able to receive the broadcast message, but only the TC application can obtain (possibly decrypt the encrypted) message's contained location information criteria. The TC application compares based on the location information criteria content of the location information table and judges whether it should report to the network by sending location information table to the TM-GW. If the TC application judges that it should report, i.e. the criteria match, the TC application sends via the certain data channel location information table, which is possibly encrypted, to the TM-GW. The TM-GW receives the message and possibly decrypts the message, and intermediates the location information/the route to the location-based service appliance.

In some various further embodiment of the invention, broadcasting can preferably be applied. The terms for the target route of the mobile station can be transferred to the selected mobile station by broadcasting. It should also be noted that the terms can change based on various conditions. For example, the terms for triggering can change based on the whereabouts and/or traveling of the mobile station. Different geographical areas, in accuracy of at least one cell, can have different triggering conditions. Correspondingly, the conditions/terms can be updated independently for different geographical areas. The triggering can, thus be based on the broadcasting and does not require any kind of inquiry or subscription/calling of the mobile

station. For example, area A can have triggering conditions A' for the traveled route A'' and area B can have triggering conditions B'' for the traveled route B''.

Some embodiments of the invention apply the location information criteria. The location information criteria indicates a time period (start/end time) and route points (CGI data), by which it is possible to determine the traveled target route of the terminal. Advantageously, various traveled target routes can be determined, and the routes can be transmitted to many terminals by a single broadcast message and only the terminal(s) that has traveled (one of) the target route(s) reports to the network. Principles of the TC application's appliance of the criteria are the following. Terminal's TC application receives location information criteria from the network by the broadcast message. For example, in GSM SMS Cell Broadcast (SMS-CB) or in UMTS Service Area Broadcast (SAB) provides means for the cellular network broadcasting. The TC application compares the location information/timestamps contained in the location information table to the target route. If the terminal has traveled within a certain time period the target route, the terminal reports to the network. The terminal reports by sending location information table to the network to the TM-GW. Alternatively, only certain location information/timestamps is responded or only an acknowledge is sent.

Still referring to the example of the location information criteria, alternatively the criteria can be delivered to the cellular mobile station via point-to-point messaging such as SMS/USSD.

Some embodiments of the invention apply the cellular mobile station. The cellular mobile stations can take a variety of forms. Examples of cellular mobile stations include cellular mobile computing devices, cellular or mobile phones, cellular portable computer devices, cellular personal digital assistant (PDA) devices. Most cellular mobile stations are also wireless devices. Wireless devices are computing or communication devices that communicate in a wireless manner with a network. Preferably, the cellular mobile station is Short Message Service (SMS) compliant operating in Global System for Mobile communication (GSM) for transmitting and receiving the SMS indicating the location information table of the cellular mobile station or receiving location information criteria. However, other messages for conveying messaging between a cellular network and the cellular mobile station are, for example, USSD (Unstructured Supplementary Services Data). The USSD provides the operator with a tool to design proprietary supplementary services. As with the SMS, USSD uses a signaling channel as a bearer. However, instead of

having the store-and-forward functionality, it is session-oriented. This means that when the user (TC application) accesses a USSD service (TM-GW), a session is established and the radio connection stays open until the user, application, or time-out releases it. Response times for interactive applications are faster. A packet switched data transfer contains the evolvement of the SMS and the USSD into the GPRS and further into the UMTS. These sophisticated cellular wireless communication networks provide the ability to transfer the message in form of packets via the wireless communication network. Also instead of the SMS, R-data offers also a way to transfer the message in IS-136 (Time Division Multiple Access, TDMA) network to a gateway element of the wireless communication network to be forwarded to service applications. The cellular mobile station can be a hand-held device which the user can conveniently carry or care. Some cellular mobile stations are tiny whereas some cellular mobile stations provide the user with more services.

Some embodiments of the invention apply the cellular mobile communication. Preferably, the invention will be described in connection with the GSM (Global System for Mobile Communication). Regarding the invention, the operation and structure of the cellular mobile communication system are not relevant, and hence they are described only to a degree that may assist in comprehending the reception of the location information from the network and the transmission of the location information table messages and the transmission of the criteria. Other applicable cellular mobile communication systems in transmitting the messages are GPRS evolvement (General Packet Radio Services) and 3G (Third generation for Mobile Communication). Short Message Service (SMS) provides an applicable example of a transmit of the short message from the mobile station via GSM to Track Master Gateway (TM-GW), and Cell Global Identity (CGI) information provides an applicable example of the location information the network is providing.

Fig. 1 has been described in the foregoing. In the following, corresponding reference signs have been applied to corresponding parts. Users have mobile stations (MS). There may be one or several mobile terminals and users, but for illustrative purposes four is shown in the exemplary Figure 1. The mobile stations (MS) may be capable of presenting data information such as text, voice, audio, and multimedia. The mobile stations (MS) may be coupled with or be under coverage of at least one cellular mobile network (100). The cellular mobile network (100) may be any type of cellular mobile communication network, including, but not restricted to, GSM (Global System for Mobile communication), GPRS (General Packet Radio

System), UMTS (Universal Mobile Telephone System) or 3G (Third generation of mobile communications), where 3G can be compatible with GSM, HSCSD (High Speed Circuit Switched Data), GPRS, EDGE (Enhanced Data Rates for Global / GSM Evolution) and WCDMA (Wideband Code Division Multiple Access). Various other cellular mobile networks can also be supported, such as CDMA (Code Division Multiple Access), PDC (Personal Digital Communications), CDMA2000. The cellular mobile network (100) contains a Radio Access Network (RAN) and a Core Network (CN). The mobile stations (MS) are couple with the Track Master Gateway (TM-GW) through the cellular mobile network 100. The TM-GW can also be referred to as a proxy server or mobile data server. The TM-GW is able to exchange information with external services residing in Internet servers. The TM-GW and the servers are interconnected via a network (102). The external servers manage the storage and appliance of location based services for mobile clients for appropriate locations. Typically, the network (102) is a wired network. As an example, the network (102) can be a local area network (LAN), a wired area network (WAN), the Internet, or some combination thereof. In one embodiment, the network (102) is the Internet and the TM-GW and the service servers are HTTP servers.

In the example of Fig. 1 the invention is applied in the GSM. Referring to Figure 1, a mobile switching center (MSC) (not shown) switches incoming and outgoing calls in the network. It also performs tasks typical of mobile telephone traffic, such as subscriber location management, in co-operation with mobile network subscriber registers a Visitor Location Register (VLR) (not shown) and a Home Location Register (HLR) (not shown). The HLR is a subscriber's home register for a permanent storage of subscriber data. The VLR is a local register to which the subscriber data is copied from the HLR when a mobile subscriber visits the area of the VLR. The Mobile Station (MS) communicates with the MSC via Radio Access Network's base station systems (BSS) (not shown). The BSS includes a base station controller (BSC) (not shown) and base stations (BTS) (not shown), for example, fixed radio transceivers by which the MS communicates with a MSC over the radio path.

Still referring to the example of Figure 1, the short message service (SMS) of the cellular mobile communication network (100) offers means for transferring short messages with limited length (140 bytes) between the cellular mobile station (MS) and a short message service center (SMSC). By means of concatenated SMS

messages, more than 140 bytes can be transmitted. The MS originated short messages are transferred from the MS to the SMSC. The short messages can be destined for some MSs or for service providers in a fixed network such as in the Internet. A protocol employed between the SMSC and the MS is called SMTP (Short Message Transport Protocol).

Still referring to Fig. 1, Cell Broadcast is a technology that allows a text or binary message to be defined and distributed to all mobile stations connected to a set of cells. Whereas SMS messages are sent point-to-point, Cell Broadcast (SMS-CB) messages are sent point-to-area. This means that one SMS-CB message can reach a huge number of terminals at once. In other words, SMS-CB messages are directed to radio cells, rather than to a specific terminal. SMS-CB is an unconfirmed push service, meaning that the originator of the message does not know who has received the message, allowing for services based on anonymity. A Cell Broadcast Entity (CBE) is a multi-user front-end that allows the definition and control of SMS-CB messages. A CBE can be located at the site of a content provider. At the site of the operator a so-called Cell Broadcast Center (CBC) is located. The CBC is the heart of the Cell Broadcast System and acts as a server for all CBE clients (TM-GW). It takes care of the administration of all SMS-CB messages it receives from the CBE(s) and does the communication towards the Radio Access Network. The GSM network itself takes care of delivering the SMS-CB messages to the mobile terminals. The CBC is operationally coupled with the TM-GW.

Still referring to Fig. 1, the USSD provides the operator with a tool to design proprietary supplementary services. As with the SMS, USSD uses a signaling channel as a bearer. However, instead of having the store-and-forward functionality, it is session-oriented. This means that when the user (TC application) accesses a USSD service (TM-GW), a session is established and the radio connection stays open until the user, application, or time-out releases it. Response times for interactive applications are faster. The USSD Center (USSDC) is operationally coupled with the TM-GW in the Core Network.

Still referring to the example of Figure 1, the SMSC is operationally coupled with the mobile communication network 100 via the MSC. The SMSC is also operationally couple with the TM-GW. The MSC relays short messages between the MS and the SMSC, and it performs the HLR (and VLR) inquiries possibly needed for the message in the communication. The SMSC is given a dedicated ISDN number in the number space of the mobile communication network, and the MS

uses the ISDN number for addressing a short message to the SMSC. The short message also identifies the MS when the network originated data information is to be obtained.

Still referring to the exemplary Figure 1, the SMSC, the CBC, and the USSDC are operatively coupled with the TM-GW. The TM-GW is operationally coupled with the network 102 such that it can serve as a gateway between the mobile communication network 100 and the network 102. Thus, the MS can be coupled with the external location based application server via multiple network platforms. Accordingly, preferred embodiments of the invention enable location-based services with reduced or very small network stress. A delivery means between the MS and servers is in the cellular mobile network by the SMS or broadcast message and packet-based messages. As described below in detail, the locating is terminal-based and applies existing locating information. A large number of users, local networks and server computing systems may be connected and operated by the system. The system of the embodiment in Figure 1 is very advantageous because it can be introduced into the existing GSM networks.

Still referring to Fig. 1, the MSs are shown to be under coverage of cells (A, B, C and D). The target route in the exemplary Fig. 1 is from cell A to D via B and C (A – B – C – D). For example, the appropriate location information table, criteria and traveling the target route triggers the TC application to report location information table of the MS to the TM-GW.

Figures 2 - 4 depict in a form of a flow chart some methods for locating the cellular mobile station based on terminal-based location in accordance with embodiments of the invention.

Fig. 2 has been described in the foregoing. In the following, corresponding reference signs have been applied to corresponding parts. Fig. 2 depicts a method for a terminal-based locating. In step 200, the TC application receives cellular network location information from the cellular network. Preferably, the CGI information provided by the GSM network is received. In step 202, the TC application compares received cellular network location information to stored previous cellular network location information. The processing of the received cellular network location information is mainly based on the conventional cellular network location information processing in the cellular mobile station. If there is no substantial change in the cellular network location information, the process idles

back to step 200. If the TC application detects a change in the received cellular network location information compared to the previous, received cellular network location information and the timestamp are stored into the location information table in step 204. Preferably, the data is recorded into the SIM card. Moreover, the timestamp indicating a certain point in time is recorded for each piece of location information. Thus, the step 202 is performed when a certain condition is fulfilled. For example, a change in the location information triggers the recording. For another example, if the cellular mobile station moves into another cell, the cellular network location information changes accordingly, and the recording takes place. For another example, the checking of the change of the location information is performed periodically. Alternatively, the storing of the cellular network location information takes place periodically after a certain time limit. A ring/loop buffer is applied as a data structure for storing the cellular network location information and the timestamp, and the oldest location information is overwritten if necessary in step 204. In step 206, there is checked, whether location information criteria exists. The TC application may receive the broadcasted location information criteria and store the criteria. If the TC application detects that location information criteria is fulfilled, the MS sends location information table containing cellular network location information and timestamp to the TM-GW. For example, if the terminal has traveled the target route, which is determined in the received location information criteria, the criteria are fulfilled. For another example, the time dimensions can be applied as well. Thus, if the target route is traveled within a certain period of time the criteria are fulfilled. In the step 208, the terminal reports by sending location information table to the network to the TM-GW. Alternatively, only certain location information/timestamp is responded or only acknowledge is sent. In step 210, the TC application receives location request from the network. The TM-GW has received location request and forwarded the location request to the TC. The location request is send to specific TC application(s) via SMS/USSD channel. Thus, the location request is based on point-to-point messaging. The location request may specify a certain time period and/or certain location areas. In step 212, the TC application checks location information table. The location information table contains all stored cellular network location information and timestamp(s). As described previously in the step 208, the TC application transmits location information table containing cellular network location information and timestamp(s) to the TM-GW. For example, the location information table is sent to the TM-GW. In step 214, the TC application receives the broadcast message. The broadcast message contains the updated location information criteria for certain cell area. In

step 216, the TC application checks whether the location information criteria is changed. The TC application compares the received criteria to stored location information criteria. If the criteria are changed, the TC application updates the location information criteria and stores it. The process may continue in the step 206.

Fig. 3 has been described in the foregoing. In the following, corresponding reference signs have been applied to corresponding parts. Fig. 3 depicts a method for a terminal-based location in accordance with gateway embodiments. In step 300, there is being received a location service request for locating a mobile terminal. The TM-GW receives the location service request from location-based service server for obtaining location information. The TM-GW checks whether it has valid/updated location information table (step 302). The step 302 is optional and can be bypassed. The TM-GW may store the requested/obtained location information table for reducing further the network communication resources. If the TM-GW has valid location information (and the timestamps), it can directly report the location information table to the server. In step 304, the TM-GW creates and sends the location information request to MS via the cellular mobile network (100). Preferably, the TM-GW creates SMS/USSD compatible request for being transferred to the TC application via the cellular mobile station. In step 308, the TM-GW receives the location information table from the TC application via SMS/USSD. The TM-GW may optionally store/update received location information and timestamp(s) (step 310). Thus, the TM-GW may contain a cache for maintaining location information tables of certain cellular mobile stations. In step 312, the requested location information, and possibly the route of the MS, is reported to the location based service server.

Fig. 4 has been described in the foregoing. In the following, corresponding reference signs have been applied to corresponding parts. Fig. 4 depicts a method for a terminal-based location in accordance with broadcast based gateway embodiments. In step 400, the TM-GW receives the location information criteria for locating certain cellular mobile station(s). In step 402, the TM-GW codes in accordance with the location information criteria a binary broadcast message that contains the target route, time period, a data channel for reporting the location information table, and TM-GW server's address information. The broadcast message can advantageously be broadcast to one or several cells (step 404). A cell can contain several different criteria containing broadcast message as active at the same time, because, for example, the order of transmission can be circulated

periodically in the cell. In step 406, the TM-GW receives location information table from the TC application via SMS/USSD. Again, location information table can be stored (step 408), and location information/the route is forwarded to location-based service server via the network (200).

For another example of the embodied arrangement, the external location information application operating in Internet sends a location request to the TM-GW for obtaining requested location information of the cellular mobile station. The TM-GW forwards (or creates an equivalent location request) and sends the request to the TC application via SMSC/USSDC. The TC application reports within the requested time interval contained location information and timestamps via a certain transport channel and via TM-GW server to the requested location based application in Internet.

For another example of the embodied route appliance, location based service application in Internet transmit location information criteria to the TM-GW for locating certain cellular mobile stations. The location information criteria comprise information on the target route. For example, in the example of Fig. 1 the cellular mobile station has to be traveled from cell A to cell D via cells B and C within a period of 15 minutes (route A – B – C – D), and the CGI is applied as a unique cell identity. The TM-GW codes in accordance with the location information criteria a binary broadcast message that contains the object route, time period, a data channel for reporting the location information table, and TM-GW server's address information. The broadcast message can advantageously be broadcast to one or several cells. A cell can contain several different criteria containing broadcast message as active at the same time, because, for example, the order of transmission can be circulated periodically in the cell.

Some embodiments of the invention apply encrypting of the request message. The broadcast message can be transmitted as encrypted via the broadcast channel. Some known block cipher can be applied such as 3DES (Data Encryption Standard), as while installing, the TC application's memory contains the same stored encrypted key as there is stored in the TM-GW. The TC application can request new encrypted key from the TM-GW, if the TC application cannot decrypt the location information criteria in the received broadcast message of the cell. For example, if the cellular mobile station has moved into another cell and decrypting is not possible, the TC application can request and receive the decryption key from the TM-GW via USSD/SMS. In addition, the TM-GW can after a certain period of time update

encrypted keys for certain another period of time by transmitting a broadcast message or point-to-point message.

Fig. 5 has been described in the foregoing. In the following, corresponding reference signs have been applied to corresponding parts. Figure 5 depicts an exemplary cellular mobile station for terminal-based location in cellular mobile network in accordance with an embodiment of the invention. The TC application is accommodated in the cellular mobile station (MS). The TC application comprises an integrated independently operating application which is stored in the SIM card as SIM Application Toolkit (STK) application. Alternatively, the TC application is operated by the operating system of the MS or a virtual machine residing in the MS. The TC application is started immediately as the MS logs into the cellular network. When the cellular network location information of the MS is changed, TC application records the CGI code and the timestamp into the TC application's location information table. Cell Global Identity (CGI) information uniquely identifies the location in GSM network. In the GSM network applied CGI code takes without compression approximately 7 bytes memory space. The CGI code comprises a Mobile Country Code (MCC, 3 digits/10 bits), Mobile Network Code (MNC, 2-3 digits/10 bits), Location Area Code (LAC, 5 digits/16 bits or less) and Cell Identity (CI, 5 digits/16 bits). As the applied timestamp approximate 7 bytes length clock time inquired from the MS can be applied. Alternatively, the clock time can be inquired from the network. The timestamp contains hours, minutes, seconds and the date. Although the network's clock and MS's clock are not synchronized, there is not inconsistency, because the selected clock (either MS or network) is applied consistently, and any synchronization error poses no distortion. Current SIM has at least 64 kB memory, and there can be occupied approximately 32 kB for the TC application's data structure. Therefore, approximately 2300 different location information table fields can be recorded, because Binary Coded Decimal (BCD) coded (2 digits/byte) CGI and timestamp occupies 14 bytes memory. Therefore, relatively long traveled route can be stored and the location criteria for triggering the reporting of the location information table can be complex, if necessary. Every subscriber's TC application, which is in the SIM, performs the tracking of the MS in real time (online) without loading/stressing the network (network communication resources). The network is loaded only, when the location information table is requested/reported from the MS to the external application.

Still referring to the example of Fig. 5, the TC application can also be downloaded into the cellular mobile station, and the execution of the data file installs the TC application for operation readiness into the cellular mobile station. The SIM card and the TC application contained in the SIM card can be releasable attachable to the terminal. Therefore, installing the TC application can be fairly simple.

Figure 6 shows an exemplary location information table. The example of Fig. 6 illustrates functional example of the location information table, and the Cell Identity (CID) can be derived from the CGI, and the entire CGI information can be stored as well. The example of Fig. 6 contains Cell Identity (CID) for uniquely identify the cell area of the cellular mobile network. The table contains also timestamp for each CID. The timestamp indicates when location information is stored into the table. Advantageously, CID and the timestamp show the route which the cellular mobile station has traveled.

Figure 7 shows exemplary location information criteria. The example of Fig. 7 illustrates functional example of the location information criteria, and the Cell Identity (CID) can be derived from the CGI, and the entire CGI information can be stored as well. The example of Fig. 7 contains the CID and task list. The CID shows the required route. The timestamps are applied to determine the route for the criteria. Moreover, the CID shows the appropriate cell. If the CID criteria are fulfilled, the TC application proceeds to the task list. For example, if the TC application is located in cell D, and the TC application has traveled route from cell B to cell D within 1 hour, the criteria are fulfilled. The TC application is triggered to transmit location information and timestamp(s) to the TM-GW.

Various location based-services can be based on and applied in accordance with the preferred embodiments of the invention.

The TM-GW/location-based service server can advantageously create a map of the traveled route of the cellular mobile station in accordance with the obtained location information table. Alternatively if the cellular mobile station has enough processing power, it can create the map.

Particular implementations and embodiments of the invention have been described. It is clear to a person skilled in the art that the invention is not restricted to details of the embodiments presented above, but that it can be implemented in other embodiments using equivalent means without deviating from the characteristics of

the invention. The scope of the invention is only restricted by the attached patent claims. For example, the location accuracy has been described in connection with a cell. If any area of a cell can be determined by the cellular network location information, for example, by applying transmission RX level, the location accuracy is consequently increased.

Claims

1. A method for terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the method comprising the steps of:

receiving cellular network location information from the cellular mobile communication network at the cellular mobile station, and

storing, at the cellular mobile station, the cellular network location information and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

2. A method according to claim 1, wherein the traveled route of the cellular mobile station in the cellular mobile communication network is adapted to be determined at a gateway to which cellular network location information and timestamps are transferred via the cellular mobile communication network.

3. A method according to claim 1, wherein the cellular network location information comprises Cell Global Identity (CGI) code of a GSM network.

4. A method according to claim 1, wherein the cellular network location information comprises Mobile Country Code (MCC), Mobile Network Code (MNC), Location Area Code (LAC), and Cell Identity (CI).

5. A method according to any of the preceding claims, wherein cellular network location information is delivered to the cellular mobile station in a broadcast dependent manner via broadcasting channels of the cellular mobile communication network.

6. A method according to claim 1, further comprising the step of receiving, at the cellular mobile station, broadcast message containing location information criteria from the cellular mobile communication network, and

storing the location information criteria at the mobile station, wherein the location information criteria indicate conditions or terms about movement of the cellular mobile station and the cellular network location information based route points, by which it is possible to determine a traveled target route of the cellular mobile station.

7. A method according to claim 6, wherein the conditions or terms can be different for at least two different geographical areas.

8. A method according to claim 1, further comprising the step of receiving, at the cellular mobile station, broadcast message containing location information criteria from the cellular mobile communication network, and

storing the location information criteria at the mobile station, wherein the location information criteria indicate a time period for setting time limits for movement of the cellular mobile station and the cellular network location information based route points, by which it is possible to determine a traveled target route of the cellular mobile station.

9. A method according to claim 6 or 8, further comprising the step of comparing the target route contained in the location information criteria to the stored cellular network location information and timestamps, and

sending a message for responding to the step of comparing, if the target route matches to the traveled route of the cellular mobile station indicated by the stored cellular network location information and timestamps.

10. A method according to claim 6 or 8, further comprising the steps of receiving another location information criteria at the cellular mobile station,

comparing the stored location information criteria to the received another location information criteria, and

storing the another location information criteria, if the another location information criteria specifies updated criteria for triggering a transmission of the cellular location information and the timestamps.

11. A system for terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the system comprising:

the cellular mobile communication network for providing the cellular mobile station with cellular network location information, and for transferring a message between the cellular mobile station and a gateway,

a RF section for receiving cellular network location information from the cellular mobile communication network at the cellular mobile station,

means for storing, at the mobile station, cellular network location information as such as received and a timestamp for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network,

the gateway for bridging communication between the cellular mobile communication network and a computing network, and for receiving a message containing stored cellular network location information and timestamps from the cellular mobile station for determining a traveled route of the cellular mobile station, and

a location-based service server in the computing network for providing location based service for a user.

12. A cellular mobile station for terminal-based tracking, the cellular mobile station adapted to operate in a cellular mobile communication network, the cellular mobile station comprising:

a RF section for receiving cellular network location information from the cellular mobile communication network at the cellular mobile station,

means for storing, at the cellular mobile station, cellular network location information as such and a timestamp for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

13. A cellular mobile station in accordance with claim 12, wherein the means for storing comprises one of a SIM card of the cellular mobile station, and a memory of the cellular mobile station.

14. A releasable attachable data card for a cellular mobile station adapted to operate in the cellular mobile communication network, the data card comprising:

an interface for receiving cellular network location information from the cellular mobile communication network, and for being coupled with a RF section of the cellular mobile station, and

means for storing, at the data card, the cellular network location information as such and timestamps for each piece of cellular network location information indicating a

means for storing, at the mobile station, cellular network location information and a timestamp for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network,

the gateway for bridging communication between the cellular mobile communication network and a computing network, and for receiving a message containing stored cellular network location information and timestamps from the cellular mobile station for determining a traveled route of the cellular mobile station, and

a location-based service server in the computing network for providing location based service for a user.

12. A cellular mobile station for terminal-based tracking, the cellular mobile station adapted to operate in a cellular mobile communication network, the cellular mobile station comprising:

a RF section for receiving cellular network location information from the cellular mobile communication network at the cellular mobile station,

means for storing, at the cellular mobile station, cellular network location information and a timestamp for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

13. A cellular mobile station in accordance with claim 9, wherein the means for storing comprises one of a SIM card of the cellular mobile station, and a memory of the cellular mobile station.

14. A releasable attachable data card for a cellular mobile station adapted to operate in the cellular mobile communication network, the data card comprising:

an interface for receiving cellular network location information from the cellular mobile communication network, and for being coupled with a RF section of the cellular mobile station, and

means for storing, at the data card, the cellular network location information and timestamps for each piece of cellular network location information indicating a

unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

15. A computer program product comprising a program of instructions executable by a computing system for processing terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the computer program product comprising:

computer program code for causing the system to receive cellular network location information from the cellular mobile communication network at the cellular mobile station, and

computer program code for causing the system to store, at the cellular mobile station, the cellular network location information as such as received and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

15. A computer program product comprising a program of instructions executable by a computing system for processing terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the computer program product comprising:

computer program code for causing the system to receive cellular network location information from the cellular mobile communication network at the cellular mobile station, and

computer program code for causing the system to store, at the cellular mobile station, the cellular network location information and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

AMENDED CLAIMS

[Received by the International Bureau on 30 October 2003 (30.10.03)]

1. A method for terminal-based tracking for a cellular mobile station adapted to operate in a cellular mobile communication network, the method comprising the steps of:

receiving cellular network location information from the cellular mobile communication network at the cellular mobile station, and

storing, at the cellular mobile station, the cellular network location information as such and timestamps for each piece of cellular network location information indicating a unique location of the cellular mobile station in the cellular mobile communication network for obtaining a traveled route of the cellular mobile station.

2. A method according to claim 1, wherein the traveled route of the cellular mobile station in the cellular mobile communication network is adapted to be determined at a gateway to which cellular network location information and timestamps are transferred via the cellular mobile communication network.

3. A method according to claim 1, wherein the cellular network location information comprises Cell Global Identity (CGI) code of a GSM network.

4. A method according to claim 1, wherein the cellular network location information comprises Mobile Country Code (MCC), Mobile Network Code (MNC), Location Area Code (LAC), and Cell Identity (CI).

5. A method according to any of the preceding claims, wherein cellular network location information is delivered to the cellular mobile station in a broadcast dependent manner via broadcasting channels of the cellular mobile communication network.

6. A method according to claim 1, further comprising the step of receiving, at the cellular mobile station, broadcast message containing location information criteria from the cellular mobile communication network, and

storing the location information criteria at the mobile station, wherein the location information criteria indicate conditions or terms about movement of the cellular mobile station and the cellular network location information based route points, by which it is possible to determine a traveled target route of the cellular mobile station.

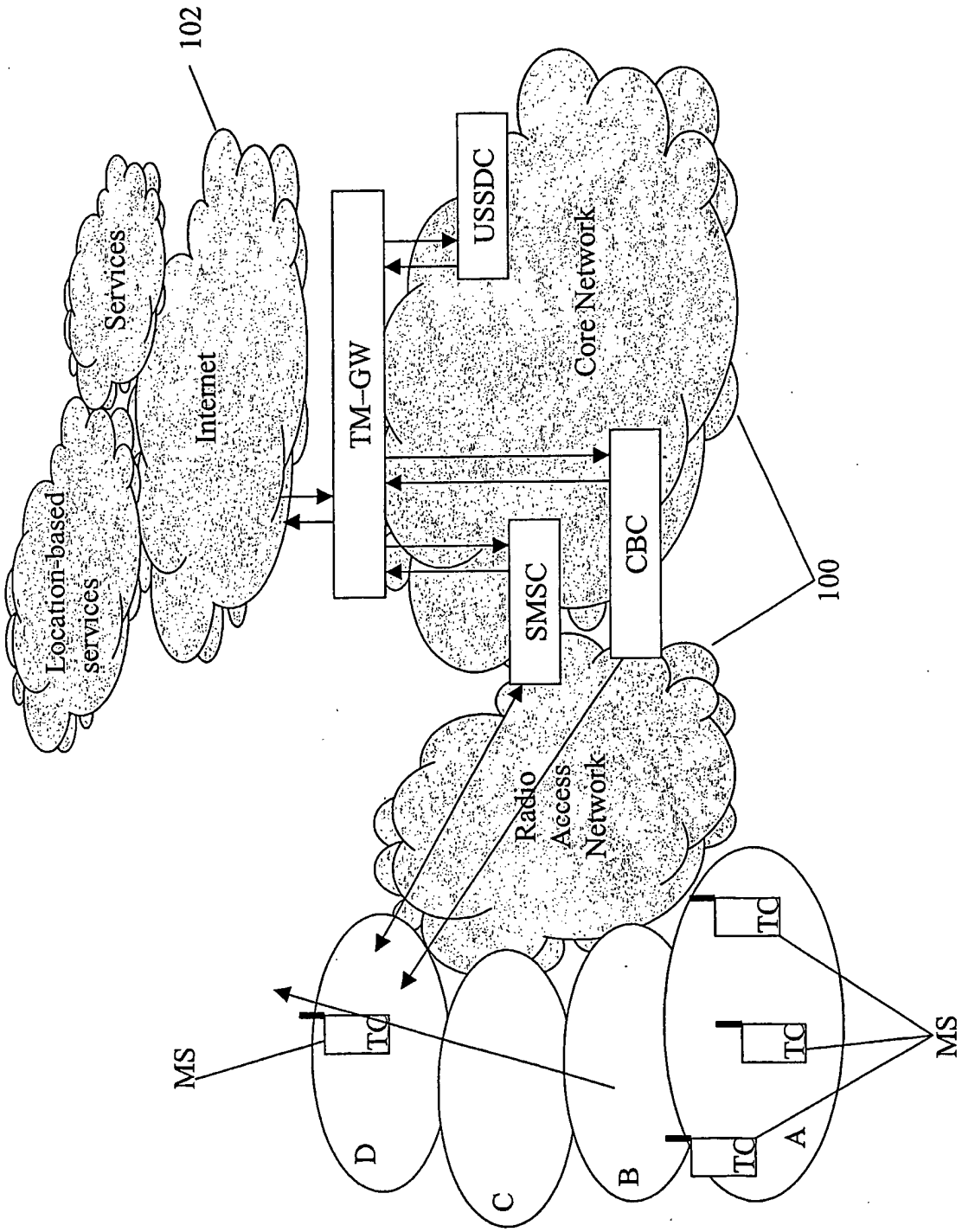
102
Location-based services
Services
Internet
TM-GW
USSDC
Core Network
SMSC
CBC
100
Radio Access Network
MS
TC
D
C
B
A
TC
TC
MS

Fig.1

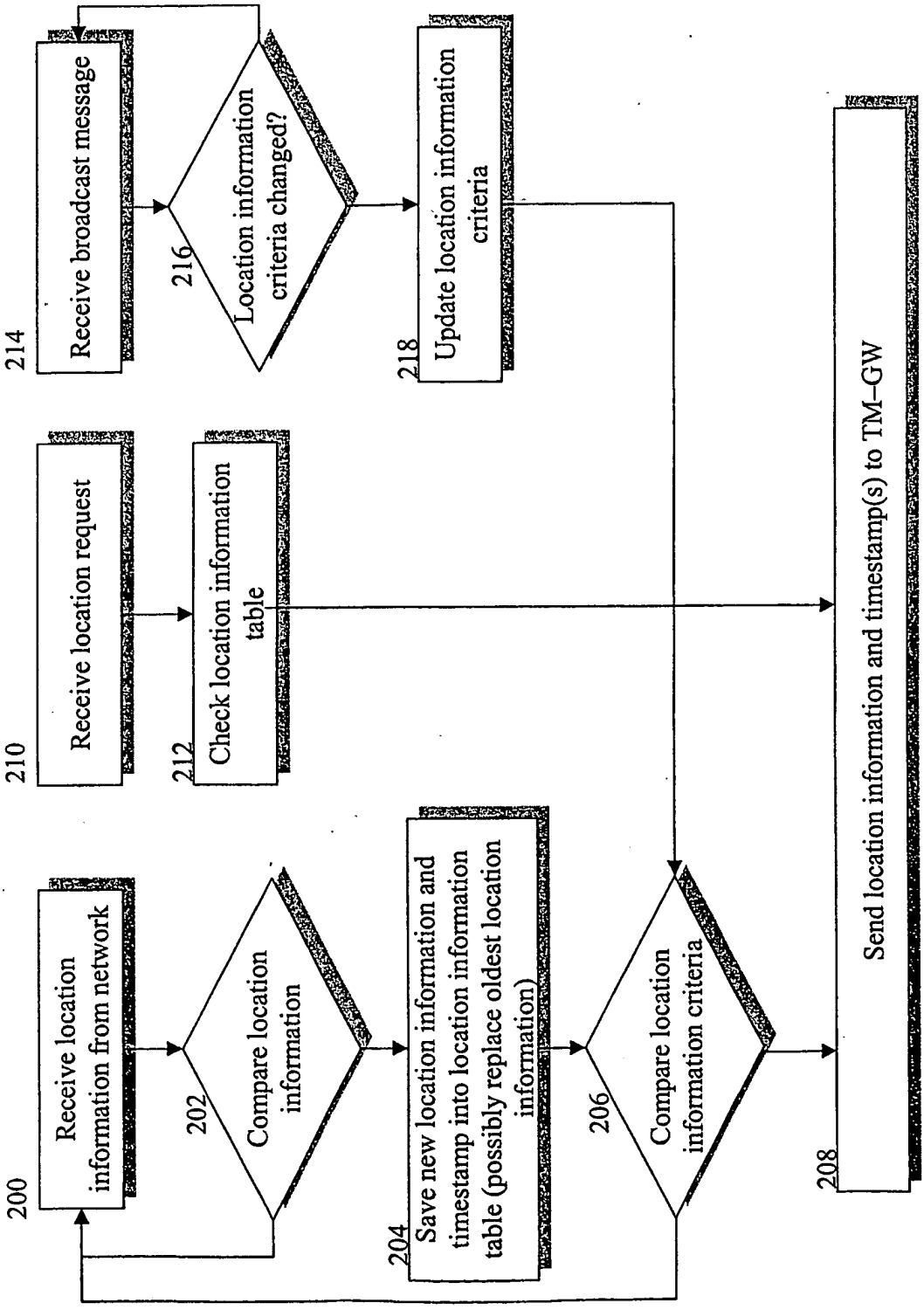
200
Receive location information from network
202
Compare location information
204
Save new location information and timestamp into location information table (possibly replace oldest location information)
206
Compare location information criteria
208
Send location information and timestamp(s) to TM–GW
210
Receive location request
212
Check location information table
214
Receive broadcast message
216
Location information criteria changed?
218
Update location information criteria

Fig.2

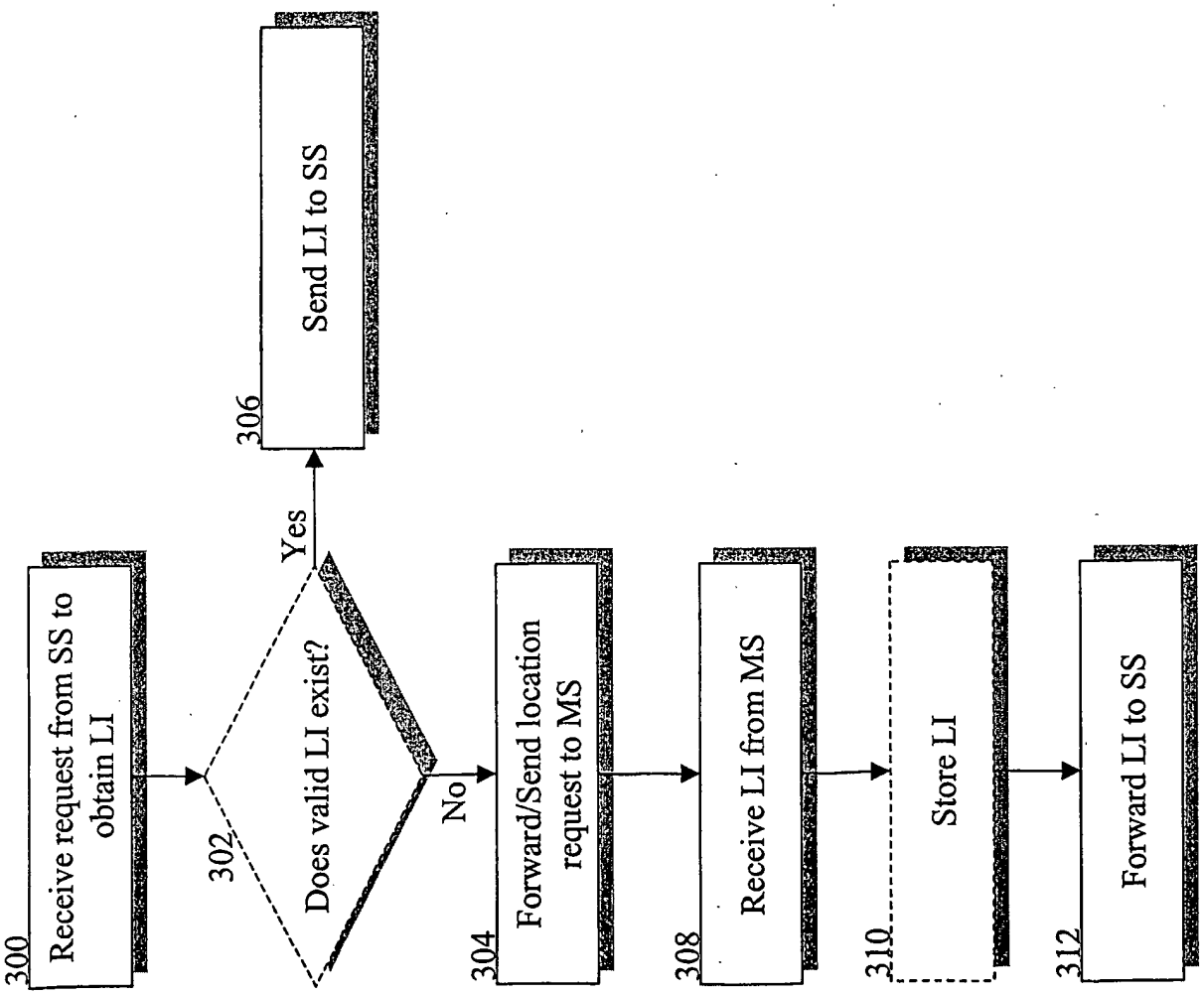
300
Receive request from SS to obtain LI
302
Does valid LI exist?
Yes
306
Send LI to SS
No
304
Forward/Send location request to MS
308
Receive LI from MS
310
Store LI
312
Forward LI to SS

Fig. 3

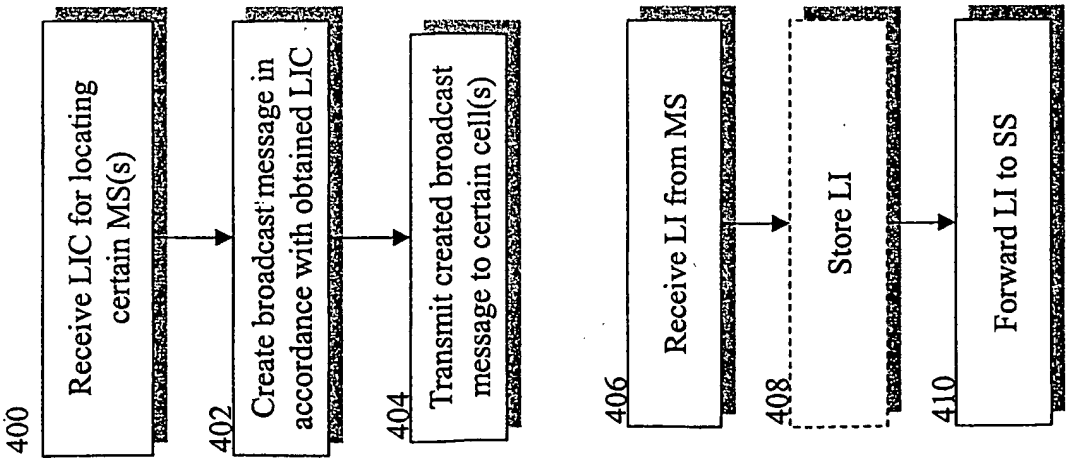
400
Receive LIC for locating certain MS(s)
402
Create broadcast message in accordance with obtained LIC
404
Transmit created broadcast message to certain cell(s)
406
Receive LI from MS
408
Store LI
410
Forward LI to SS

Fig. 4

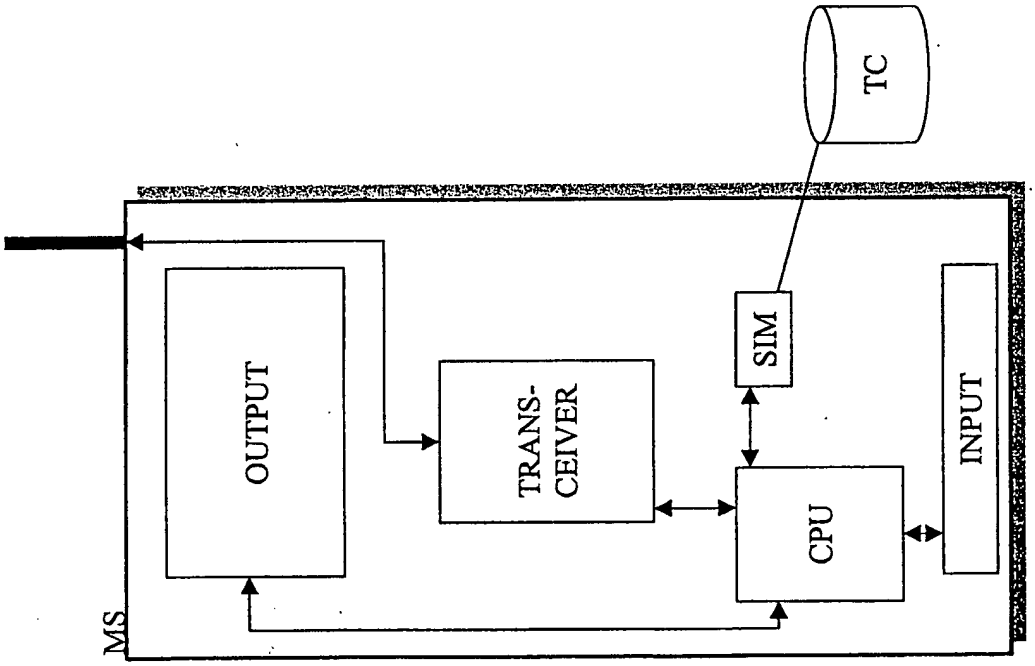

Fig. 5

CID	Timestamp
A	02.05.2002 14.48.12
B	02.05.2002 15.01.05
C	02.05.2002 15.30.08
D	03.05.2002 09.30.55

Fig. 6

CID	Task
A	-
B	-
C	-
D	Obtain message if route B – D within 1h

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 03/00449

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04Q 7/20, H04Q 7/32
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04Q, H04B, G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC,WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6295454 B1 (T.HAVINIS ET AL), 25 Sept 2001 (25.09.01), column 1, line 9 - line 14; column 2, line 41 - column 3, line 21; column 4, line 15 - line 17, col.4 li.66,col. 5 li.6,col.5 li. 31,col 5,li. 36,col. 6,li.14, col.6 li.16, fig.4,10,claim 1-4,9,13,14,19-28,abstract ---	1-15
X	GB 2352128 A (NEC TECHNOLOGIES LTD), 17 January 2001 (17.01.01), page 1, line 20 - page 2, line 5; page 4, line 19 - line 22; page 8, line 15 - line 21, claims 1-3, abstract ---	1-10,12-14

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 August 2003	01 -09- 2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Tomas Wässingbo /itw Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 03/00449

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6097958 A (S.BERGEN), 1 August 2000 (01.08.00), column 1, line 56 - column 2, line 35, abstract ---	1-15
A	WO 9933040 A1 (TRANSPORTONLINE AS), 1 July 1999 (01.07.99), page 1, line 25 - page 2, line 26, abstract --- --------	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

26/07/03

International application No.
PCT/FI 03/00449

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6295454 B1	25/09/01	NONE	
GB 2352128 A	17/01/01	GB 9915796 D	00/00/00
US 6097958 A	01/08/00	NONE	
WO 9933040 A1	01/07/99	AU 1892599 A	12/07/99
		NO 975999 A	21/06/99